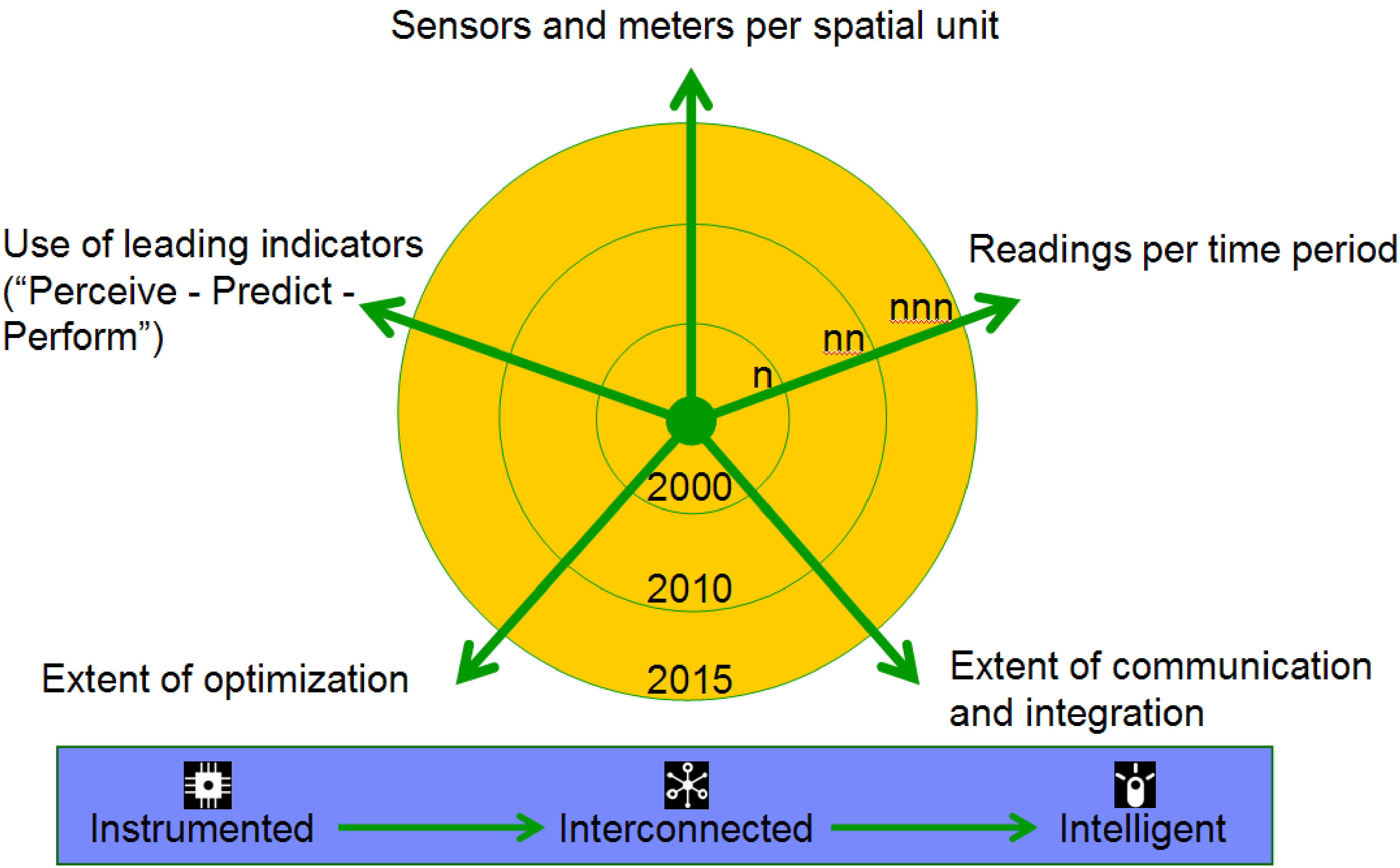
City of San Diego: Water Network Management

September 28th, 2011

Introduction

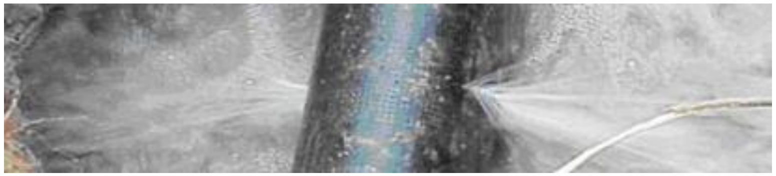
- Brady and IBM present here some ideas for applying analytic technologies to the management of San Diego's water system
  - Enabling leak detection, pressure management and potentially, energy optimization as an analytic service, linked to asset management
  - Potential benefits of greater water efficiency, reduced energy costs, reduced asset lifecycle costs and improved customer service
- Brady brings civil and water engineering expertise, and its deep experience of San Diego's water system
- IBM brings the analytics and optimization technologies with which it is building "Smarter Cities" and a "Smarter Planet"
- Our proposal is to proceed with a pilot in one or two DMA (to be determined) before rolling out city-wide
  - The longer term objective could be to elevate San Diego a "smarter water" show case for the water industry as a whole.

“A Smarter Planet”. Forget social computing! **This** is the major information technology trend of our time!!



Addressing Non-Revenue Water using Optimization

1) Leakage Detection at the Network Level using Optimization

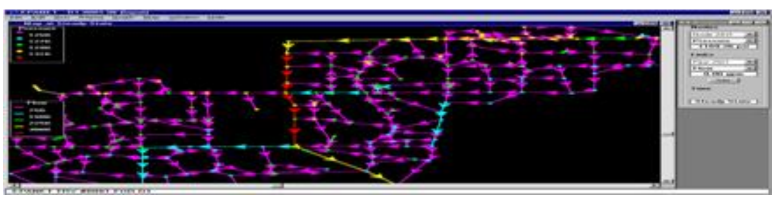


Detect anomalies between modeled performance of network and actual meter and pressure readings, to identify potential leaks – non invasively.

2) Water Loss Reduction using Dynamic Pressure Control

Dynamically adjust pressure in real time so that only the required flow will be supplied yielding reduction in water wastage, as well as reductions in energy and maintenance costs.

3) Optimal Valve Placement for Pressure Reduction



Use network model to find the optimal location of valves to enable the most effective pressure management. With leaks, this can save water and avoid worsening the leak, perhaps into a full blow-out.

4) Link with Asset Management to Enable Rapid Repairs and Maintenance Planning

Create a seamless process of “detect a leak and fix it” – reduce cost and time to fix. Also enable optimized predictive maintenance to reduce capital and asset lifecycle costs.

Leak Detection

- Begin with existing hydraulic model: predict the flow and pressure, assuming that no leaks exist
- Compare predicted values to actuals obtained from infrastructure meters, pressure and flow meters:
  - Can also use other sources if available (eg noise loggers, pump activity) but not essential
  - Takes into account external factors – weather, sports events, etc
- Repeat with every new meter reading – every 15-60 minutes. **In effect derives additional value from data you may already collect**.

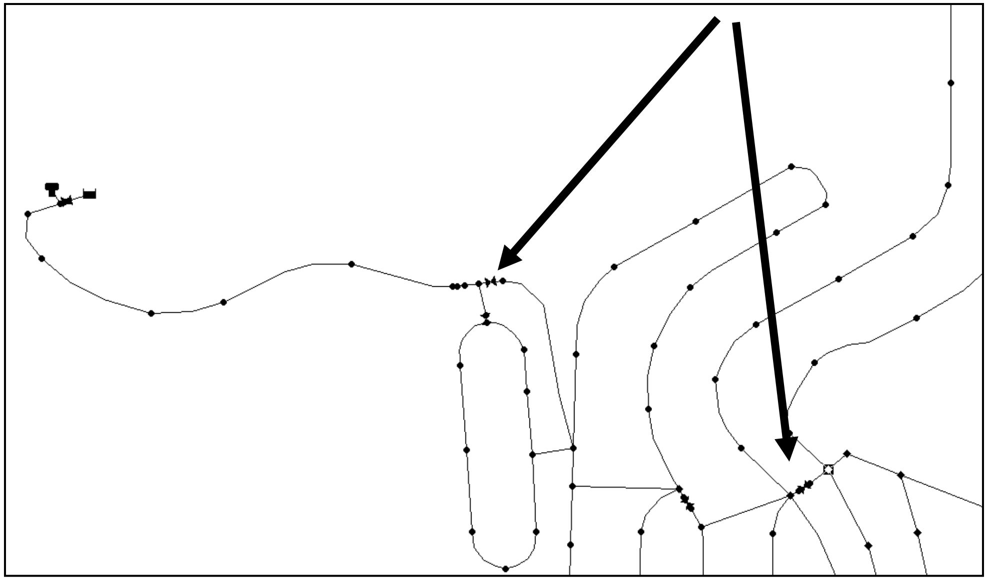
- Leaks will cause measurable differences between actual and predicted readings
  - Identify differences between predicted and actual – resolve these to the leak location that best explains the difference
- Machine learning is used to enhance the basic analysis above - detects anomalies, analyzes trends, understands behavioral trends, predicts usage.

Pressure Management

- Stopgap measure until leaks are detected, located and fixed
  - (Sufficient pressure must be maintained to provide the required time varying demand for water flow)
- Also a permanent strategy, for energy management
  - Also reduces wear in infrastructure
- Uses real time monitoring, hydraulic simulation, forecasting, and optimization techniques:
  - Water usage data is constantly collected
  - Future requirements for water is forecasted based on historical data
  - Hydraulic simulation-based optimization is used to provide appropriate valve settings so as to minimize provided pressure

Optimal Valve Placement

- In order to enable better pressure management additional valves may be needed
  – Cost of valve placement must be traded off against effectiveness in reducing pressure
- Solution Approach:
  – Run optimization tool against hydraulic model to find the optimal number of valves, and their location, so as to enable the most effective pressure management



- Same approach can also be used to identify optimum locations for additional meters and pressure gauges, to improve granularity of leak detection – provides input for capital budgeting for pipe network upgrades

Sonoma County Water Agency and Valley of the Moon Water District

- Wholesaler (Sonoma) and retailer (VofM) sharing common water inftastructure – transmission system and VofM's distribution system.
- Collaborating to test analytics-driven leak detection system:
  - Implementing pressure management
  - Leak detection to follow by Dec 2011 – based on existing bulk meter data plus additional pressure transducers.
  - Will also draw heavily on parallel project to telemeter bulk meters on transmission system
- Project to enable: pressure management (including recommended equipment settings); leak reports and size estimates (and changes to size estimates); post–earthquake system integrity check; integration with maintenance activities.
- Builds on earlier project in Tzevat, Israel
- Aim is to provide monthly service paid out of operating expenses – no capex.

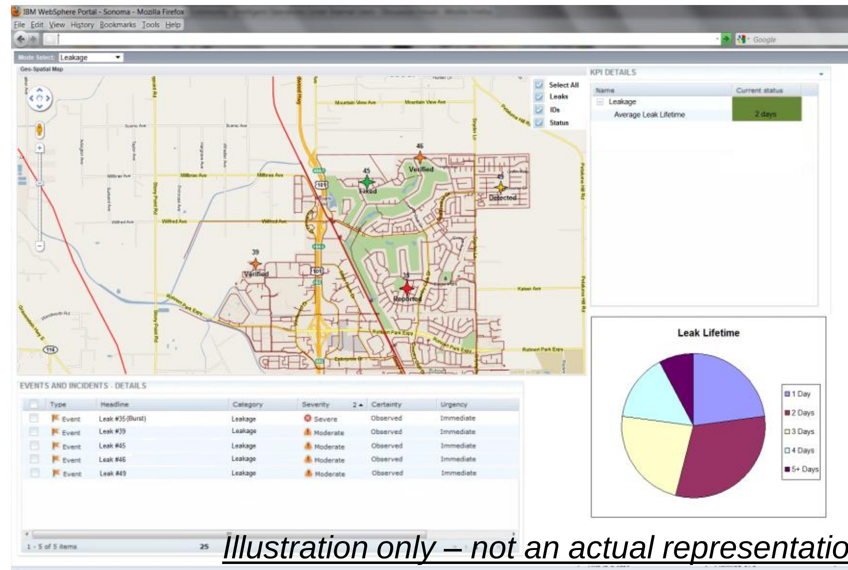


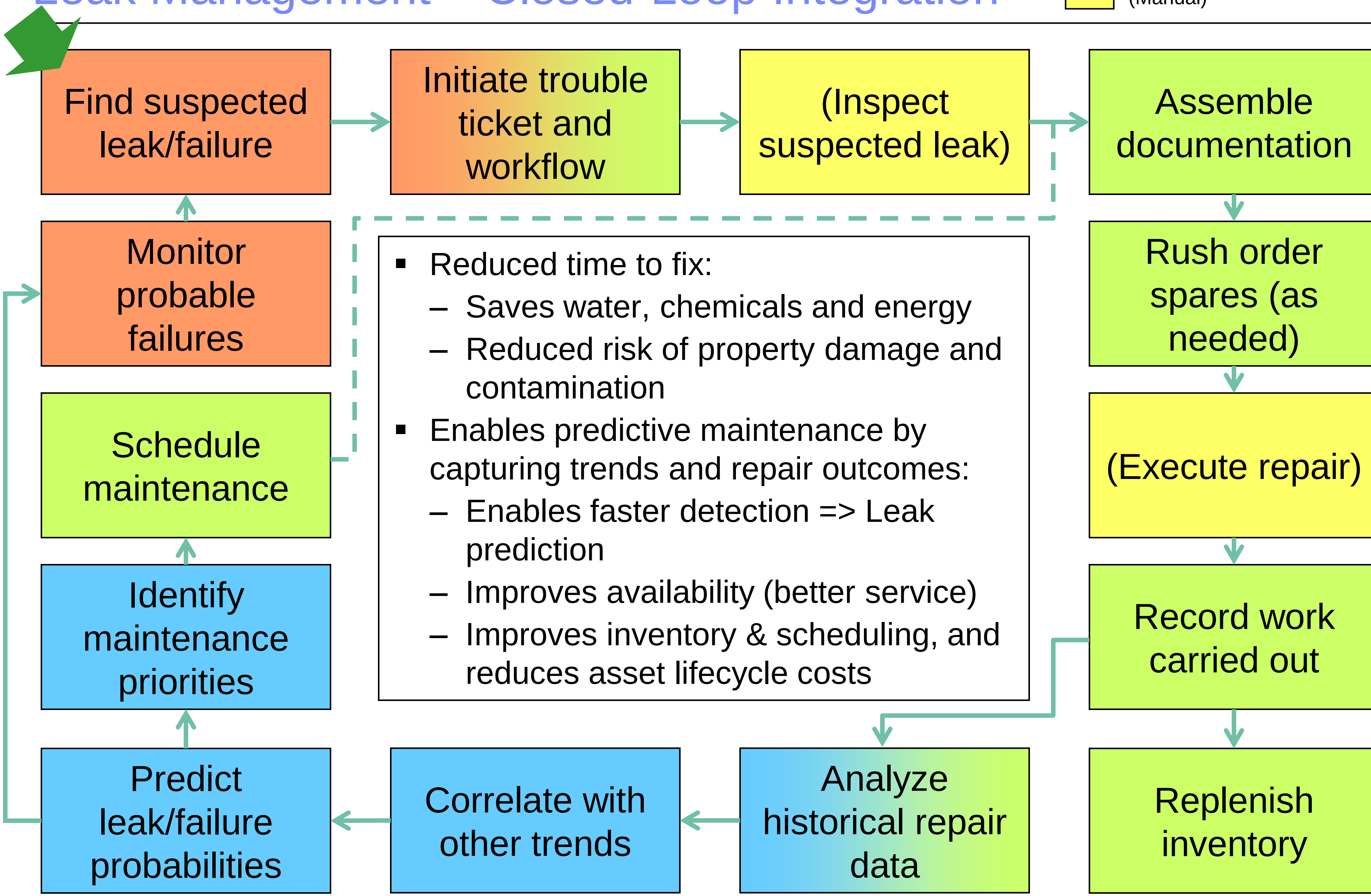
Illustration only – not an actual representation

Integrated Leak Management

- Many water agencies have one team that finds leaks (often the operations team) and another team to manage assets and undertake repairs
- Separate data and separate business processes result in:
  - Extended time to fix – additional waste of water, chemicals and energy, so additional cost
    - Additional risk of property damage and contamination
  - Missed opportunities to analyze data for predictive factors – potential indicators of pressure sensitivity, ground subsidence, distressed pipe and so on
    - Missed opportunities to reduce inventory and costs of ownership, and improve asset availability
  - Fragmented and incomplete asset history data, as repair outcomes are not captured
    - Hinders response next time a leak occurs

Leak Management – Closed-Loop Integration

Leak Detection
Maximo Asset Management
SPSS Analytics
(Manual)



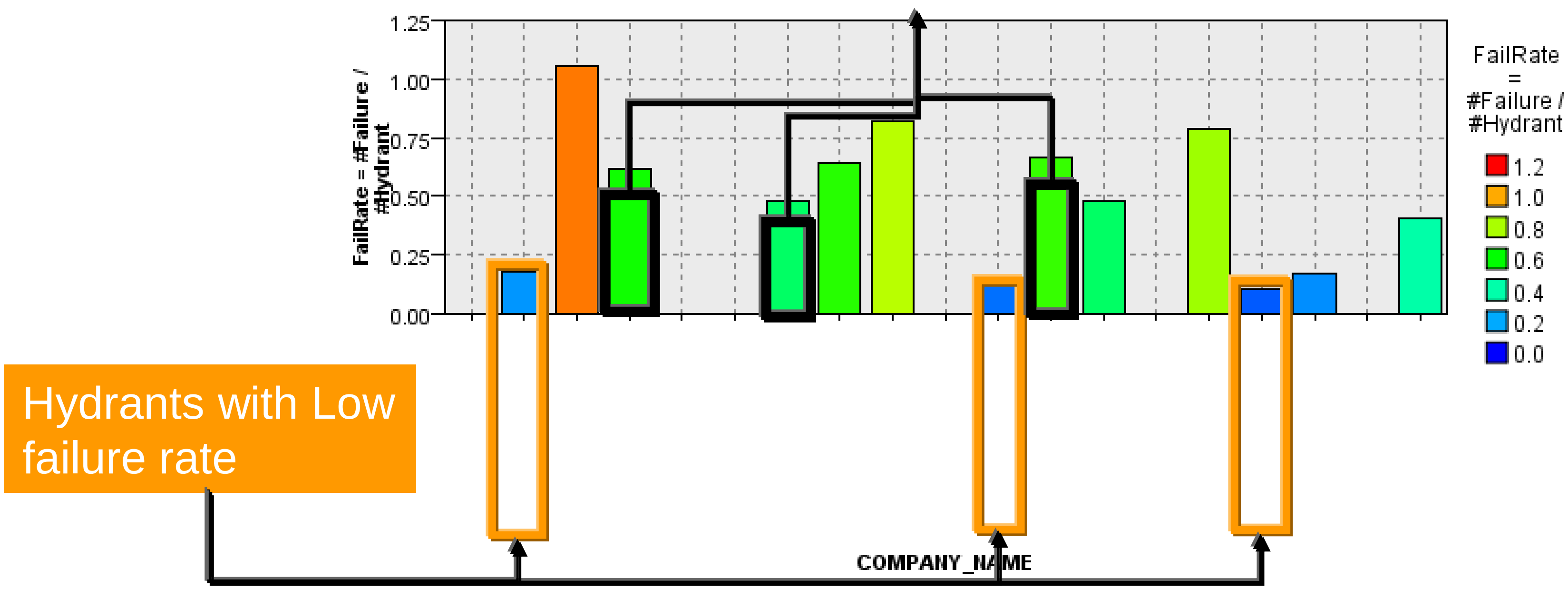
- Reduced time to fix:
  - Saves water, chemicals and energy
  - Reduced risk of property damage and contamination
- Enables predictive maintenance by capturing trends and repair outcomes:
  - Enables faster detection => Leak prediction
  - Improves availability (better service)
  - Improves inventory & scheduling, and reduces asset lifecycle costs

DC Water: Failure Associations Analysis

- Association Mining – looks at large volumes of transactions to identify correlations. Originally invented for mining retail transactions – "people who buy diapers also buy beer"

Early Results from Failure Association Mining at WASA
There is a significant association between the failure of hydrants from
Manufacturer → XXX and XXX
With FAILURE CAUSE = LEAK
When (Mean Temp >75 & < 91) & (Max Temp > 86 & <103) & (Min Temp > 65 & < 82)

XXX,XXX & XXX all have similar failure rates, but only XXX and XXX exhibits significant correlation with hot weather



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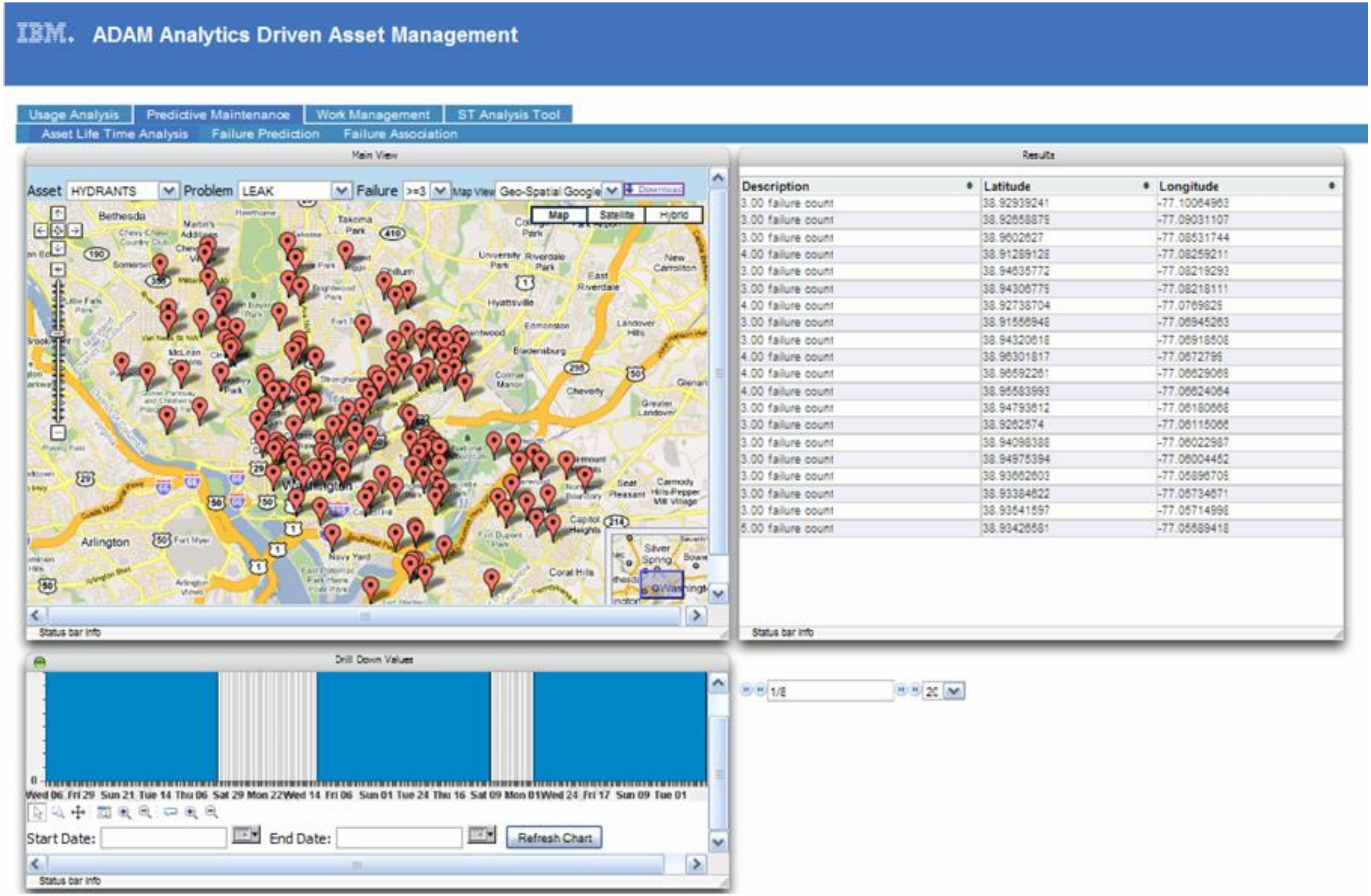
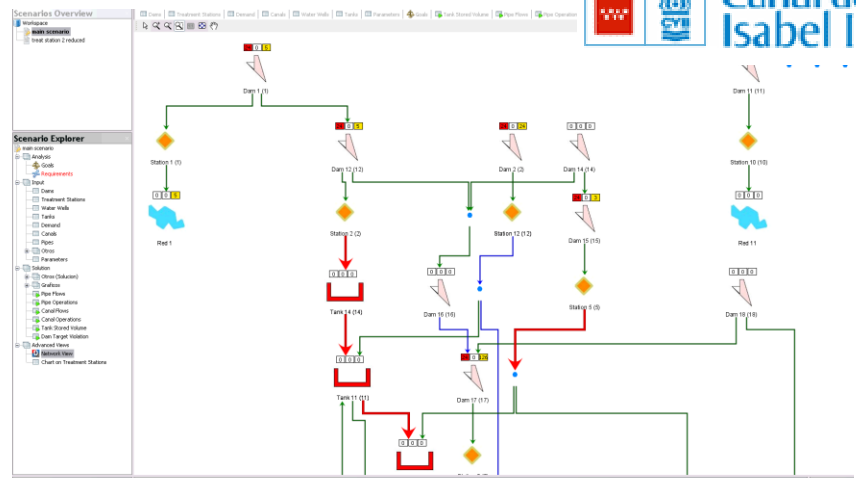
DC Water – Hydrants with more than 3 leaks in last 3 years

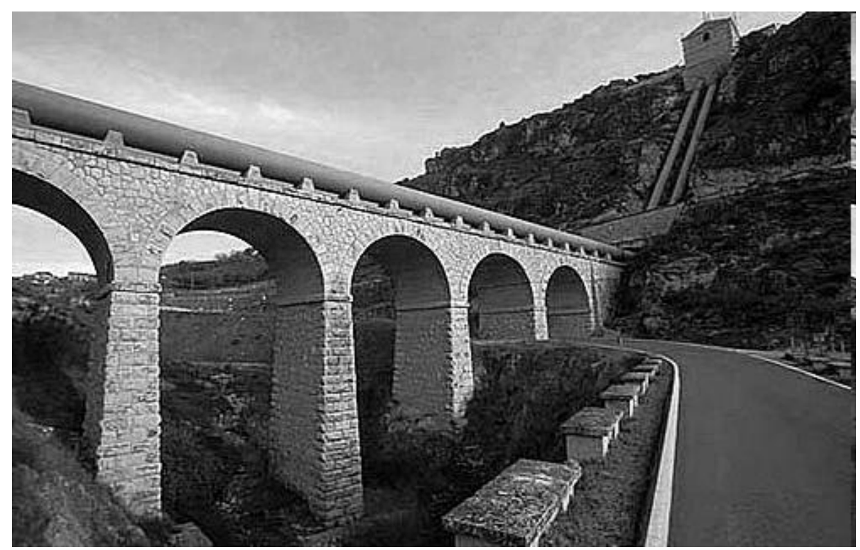


Description	Latitude	Longitude
3.00 failure count	38.92939241	-77.10064963
3.00 failure count	38.92658875	-77.09031107
3.00 failure count	38.9602627	-77.08531744
4.00 failure count	38.91289128	-77.08259211
3.00 failure count	38.94635772	-77.08219293
3.00 failure count	38.94306775	-77.08218111
4.00 failure count	38.92738704	-77.0769825
3.00 failure count	38.91556948	-77.06945263
3.00 failure count	38.94320618	-77.06918508
4.00 failure count	38.96301817	-77.0672796
4.00 failure count	38.96592261	-77.06629069
4.00 failure count	38.96583993	-77.06624064
3.00 failure count	38.94793812	-77.06180668
3.00 failure count	38.9262574	-77.06115066
3.00 failure count	38.94096388	-77.06022987
3.00 failure count	38.94975394	-77.06004452
3.00 failure count	38.93662603	-77.05896705
3.00 failure count	38.93384622	-77.05734671
3.00 failure count	38.93541597	-77.05714998
5.00 failure count	38.93426681	-77.05589418

Energy-Water Nexus: Canal de Isabel, Spain

- Energy management integrated with water routing and flow management for Madrid's water supply.
- Analytic solution created with IBM ILOG Software
- IBM also partners with Derceto (maker of dynamic energy optimization application) to offer a solution that optimizes:
  - Actual and predicted demand
  - Pipe network layout – distance alternative routes
  - Tank-turn/quality requirements
  - Pump performance, maintenance
  - Weather
  - Energy price, lowest cost
  - Dynamically, every 30 minutes…
  - And integrates with Maximo asset management to enable end-to-end pump management

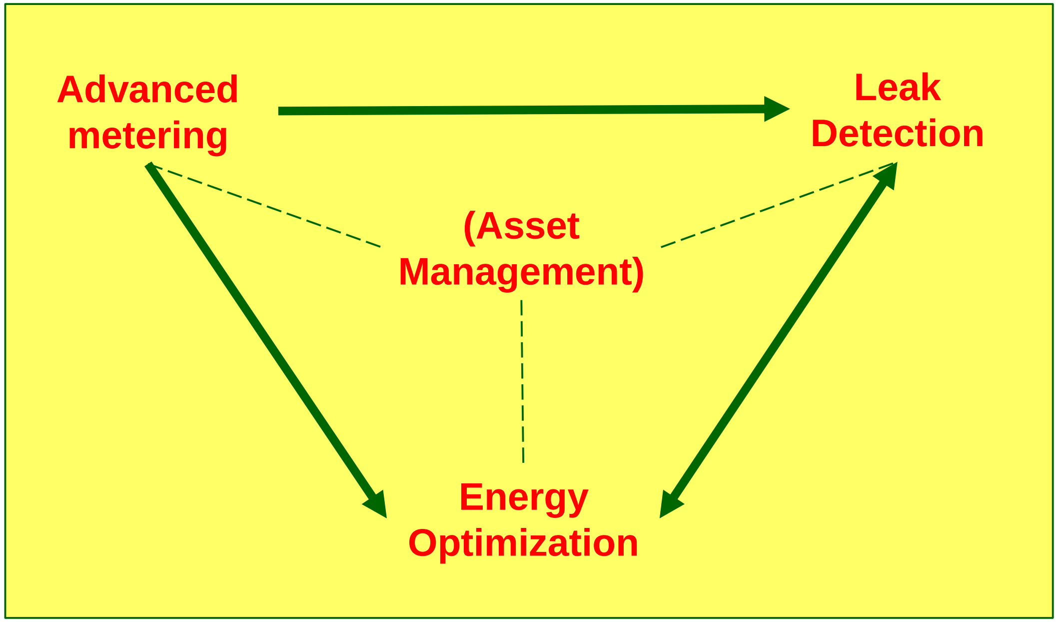




Where it might end? Metering, leak detection, energy optimization – and asset management

- Advanced metering provides granular data on flow anomalies: can be analyzed for evidence of leaks

- Advanced metering enables differential pricing which may shape demand to enable use of low cost or alternative energy resources.
- By helping illustrate leaks, advanced metering also saves energy



- Saving leaks saves energy
- Pump/energy optimization will also indicate possibility of leaks where apparent pump performance variations are not due to pump issues

- All three of advanced metering, leak detection and energy optimization will provide valuable (and timely) data on:
  - Failures or performance degradation
  - Propensity to fail – enables predictive maintenance over time – saves asset lifecycle costs.

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Next steps?

- Identify pilot area – one or two DMAs, depending on size
  - Up-to-date hydraulic model exists
  - Well instrumented and telemetered – bulk meters, flow and pressure transducers, and instruments are operational
  - Ideally, known NRW and/or pressure management problem to fix!
- Evaluate leak management and pressure management technology in these areas
  - Would be stand-alone from asset management at this stage
  - Would be off-line
  - Deliverable would be feasibility report and validation
- Establish feasibility and business case for roll-out of on-line service to whole city, and for integration with asset management
- Time-line – ~3 months, depending on completeness of data, availability of instrumentation